T-BEST 2.1

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T-BEST

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Project Team

- Florida Department of Transportation, Public Transit Office
- Center for Urban Transportation Research (CUTR)
- University of South Florida
- GeoDecisions, A Division of Gannett Fleming
- Gannett Fleming, Inc.

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Outline

1. Need for T-BEST
2. T-BEST Applications
3. T-BEST Model Concepts
4. T-BEST Analysis
5. T-BEST Software Overview
6. T-BEST Implementation
7. Conclusions
8. Future Enhancements
9. Demonstration

Need For T-BEST

- Systems Planning Software
  - Traditional 4 Step Planning Travel Models
  - Long term (20+years), Systems Level
  - Multimodal
  - Primarily Suited for Major Investment Studies

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Need For T-BEST

- Transit Operational Level Software
  - Trapeze, Hastus
  - Routing & Scheduling
  - Do Not Allow for Evaluation of Service Alternatives

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T-BEST Applications

What is T-BEST?

- Comprehensive Transit Network Modeling, Management and Analysis Software designed for short-term transit planning
- Direct and Transfer Stop-Level Boardings Estimation

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T-BEST Applications

- Service Planning
  - Stop/Route Adjustments based on:
    - ✓ Seasonal Patterns
    - ✓ Land Use Changes
    - ✓ Road Construction
    - ✓ Service Changes
  - Short-Term Ridership Forecasting
  - Adjust Socio-Economic for expected growth
  - Fare Structure changes
  - New Routes, Stops
  - New Technologies (BRT, Rail, Trolley, etc)

T-BEST Applications

- Support for Transit Development Plans
- Transit System Management
  - Network Editing/Coding
  - Integration with ArcGIS
  - Can serve as a baseline operational software

T-BEST Model Concepts

- Transit systems planning considerations:
  - Accessibility
  - Availability
  - Quality of Service
  - Ridership
  - Temporal Characteristics
  - Transfers
  - Route/Network Design
  - Fare Policies and Structure
  - Alternative Modal Options/Technologies/Route Types
  - Disaggregate Stop-Level Analysis

T-BEST Model Concepts

- Transit ridership strongly affected by:
  - Destination accessibility
  - Temporal availability
  - Network connectivity
- Desire to have T-BEST sensitive to all three aspects of transit accessibility
- Ability to test effects of alternative route and network design configurations on transit boardings

T-BEST Model Concepts

Neighboring Stops

- Riders may choose alternative stops, routes, destinations for pursuing activities
- Neighboring stops effectively capture effects of competing routes/stops
- Neighboring stops are those with overlapping buffers with subject stop
  - N1: Same Route, Same Direction
  - N2: Same Route, Opposite Direction
  - N3: Other Routes, Similar Destinations

T-BEST Model Concepts

Network Accessibility Measures

- **H_1:** Stops from which one can reach the N3 neighboring stops (Interest: Feeders for potential transfers)
- **H_2:** Downstream stops that can be reached from subject stop via the transit network (Interest: Capture potential downstream activities)
- **H_3:** Upstream stops that can be reached from the N2 stops (Interest: Capture potential upstream activities)
- **H_4:** Stops that can be reached from the N3 neighboring stops (Interest: Capture potential activities on other routes)
- **H_5:** Stops in H_4 that overlap with stops in H_3 (Interest: Capture potential competing activities)

T-BEST Model Concepts

- Computing Transit Accessibility
  - Access / Egress at Given Stop
  - Accessibility to Other Stops
- Composite Impedance Factors
  - Wait Time
  - Boarding Time
  - In-vehicle Time
  - # of Transfers
  - Transit Walking Time
  - Transfer Fare

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T-BEST Model Concepts

- Estimate Boardings at a Stop by:
  - Route
  - Direction
  - Time Period
- Model Estimates two Boarding Types:
  - Direct (Walk, Bike & Auto Access)
  - Transfer (Transit Access)

T-BEST Model Concepts

Direct Boarding Equation

$$D_n^s = f\left(R_n^s, B^s, O_{2n}^s, O_{3n}^s, O_{4n}^s, O_{5n}^s, X_n^s\right) \qquad n = 1, \ldots, N$$

- *s* refers to stop on a route in a given direction and
- *n* refers to time period
- D = direct boardings
- R = number of bus runs (arrivals)
- B = vector of buffer characteristics (population/employment)
- O_i = accessibility measures = characteristics of buffer areas of accessible stops, H_i, i = 2, 3, 4, 5
- X = vector of other route and stop characteristics

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T-BEST Model Concepts

Transfer Boarding Equation

$$T_n^s = g\left(R_n^s, O_{1n}^s, O_{2n}^s, O_{3n}^s, O_{4n,}^s O_{5n}^s, Y_n^s\right) \qquad n = 1,\ldots, N$$

- T = transfer boardings
- R = number of bus runs (arrivals)
- O_1 = accessibility measure = total boardings at all stops, H_1, during period *n* toward stop *s*
- Y = vector of other route and stop characteristics

- Methodology thus includes both direct and transfer boardings equations
- Accessibility vectors play major role

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T-BEST Model Concepts

T-BEST Data Requirements

- Transit Route & Stops Location
- Transit Route Schedule
- Transit Route & Stop Names
- Transit System
  - Fare Structure
  - Transfer Hubs
  - Interlined Routes

T-BEST Model Concepts

T-BEST Data Requirements

- Florida Source Data provided with the software:
  - 2000 Census data with pre-formatted SF1 and SF3 variables
  - 2000 InfoUSA Employment data grouped by Commercial, Industrial, and Service
  - 2000 GDT Street Networks
  - Other background GIS layers

T-BEST Analysis

Model Outputs

- T-BEST Calculates
  - Direct + Transfer = Total Boardings
  - Arrivals
  - Transfer Opportunities
- Time-Period Specific Estimations
  - Peak
  - Off-Peak
  - Night
  - Saturday
  - Sunday
- Aggregate Model Outputs by:
  - Weekday
  - Weekend
  - All Time Periods

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T-BEST Analysis

Time Period Aggregation

Example: Route 101
Inbound Stop # 10161000

Model Results by Time Period

	Peak	Off-Peak	Night	Saturday	Sunday
Direct Boardings	5	3	3	2	2
Time Period Aggregate Results	Weekday = 11			Weekend = 4	
	All Time Periods = 15				

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T-BEST Analysis

Route Level Aggregation Outputs

- Performance Measures
  - Boardings
  - Route / Service Miles
  - Service Hours
  - Boarding per Service Mile / Hour
  - Average Boarding per Service Run
- Aggregation by:
  - Route Type
  - Technology
  - Report on All Routes = System-wide Analysis

T-BEST Analysis

Area-Based Aggregation

- Summarize Model Results with a Polygon Shapefile (Districts, TAZ, Census Blocks, etc.)
- User-Defined Global Subareas
  - Analyze Model Output across multiple Scenarios

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T-BEST Reports

- Calculates Sub-Totals by Route or Planning Area
- Total for all selected inputs (stop, route, area)
- Automatic Map Display Stop-level boardings (pie chart) or area distribution

T-BEST Software

Comprehensive Model System

- Manage Multiple Transit Systems
- Scenario/Alternative Management Tools
- Update Base Year Model
- Internal Model Runs
- Unlimited Analysis potential

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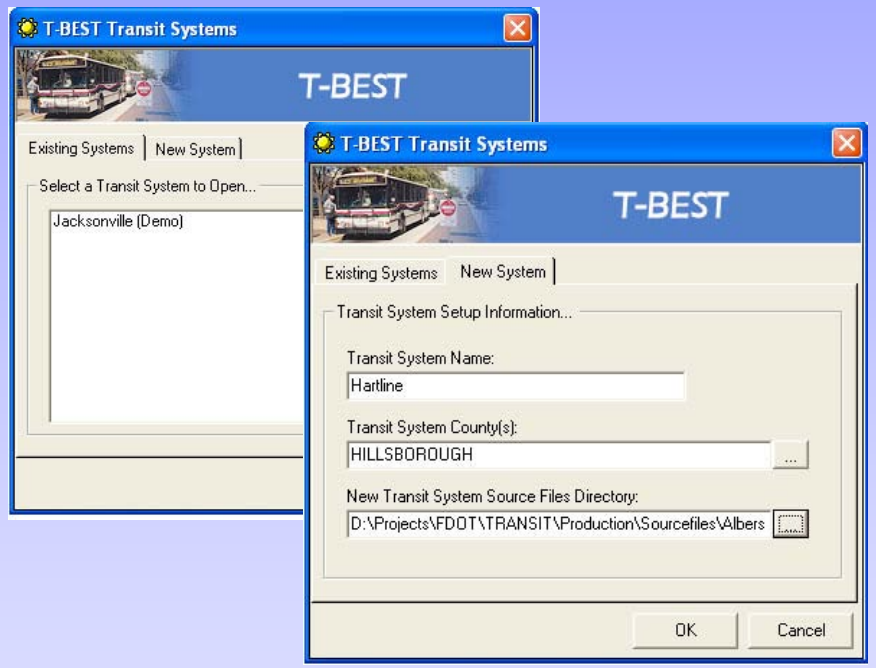
T-BEST Software

Transit System Management



- Create new Transit Systems
- Manage Existing Transit Systems
- Delete Systems
- All Files/Data managed internal in the software

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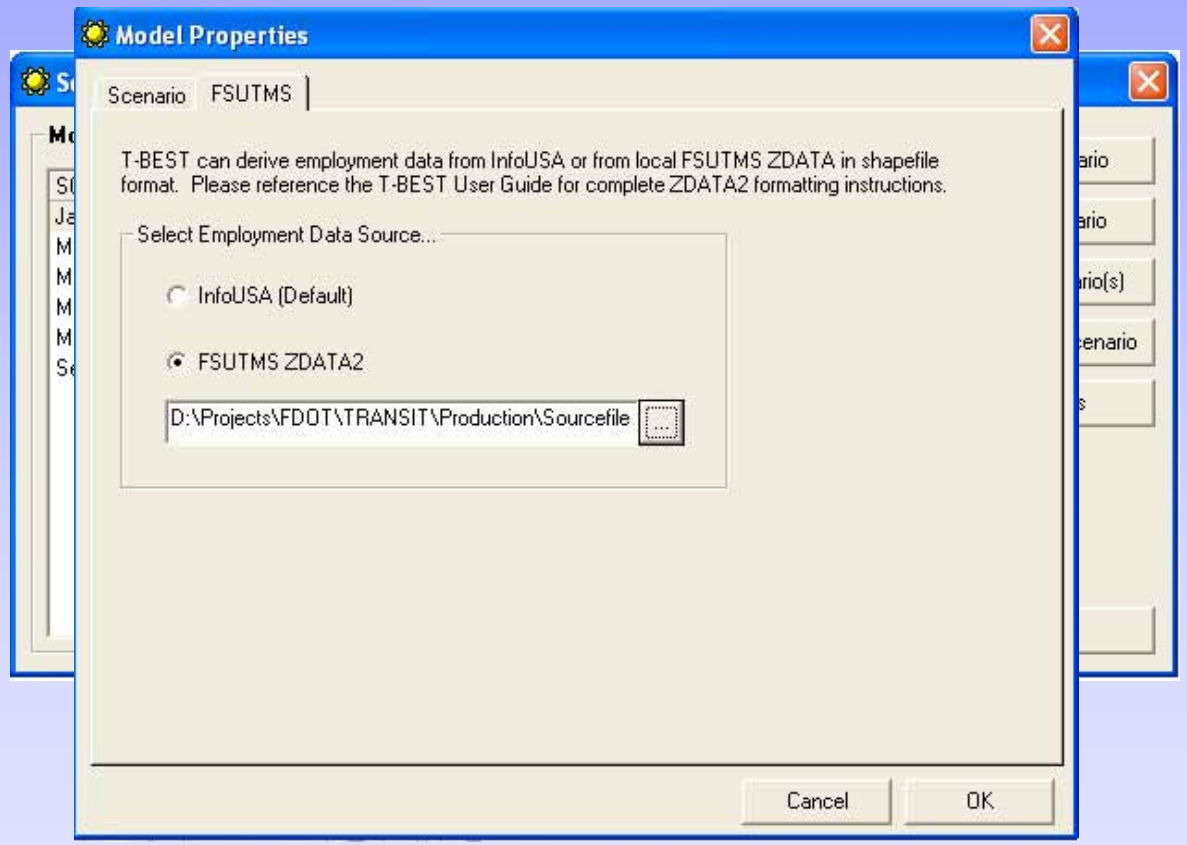
T-BEST Software

Scenario/Alternative Management



- Manage Alternatives
- Create Base Year Model
- Adjust Socio-Economic Variables to Future Year
- Incorporate Local Employment Data

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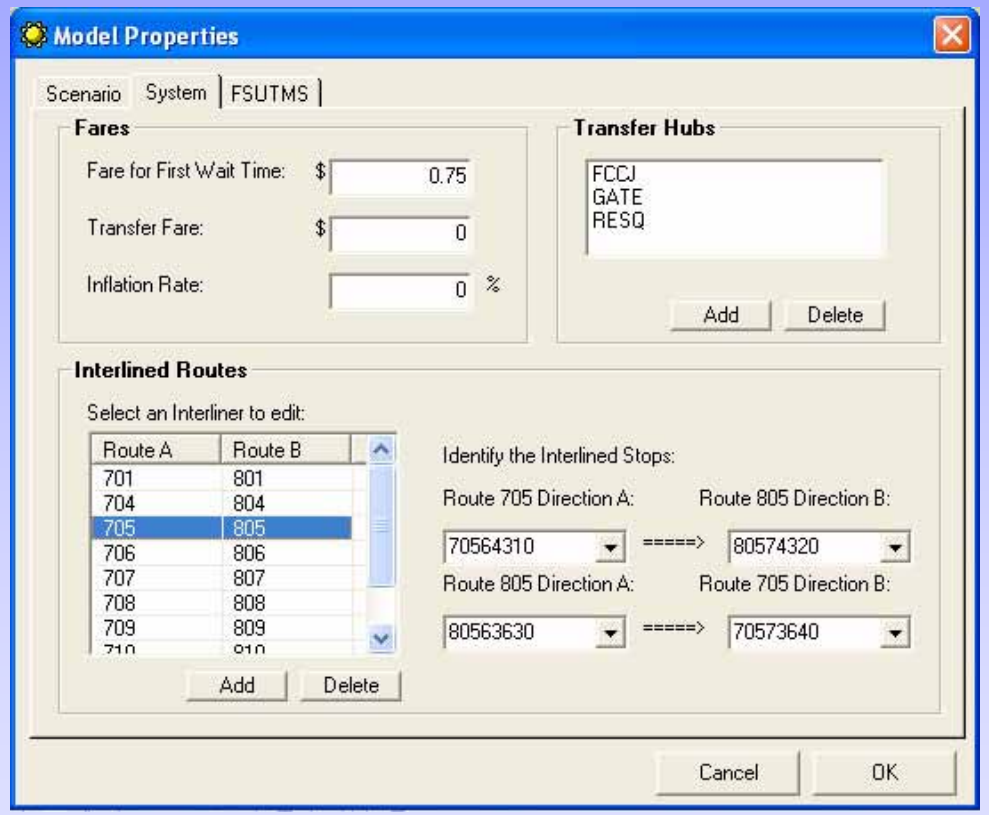
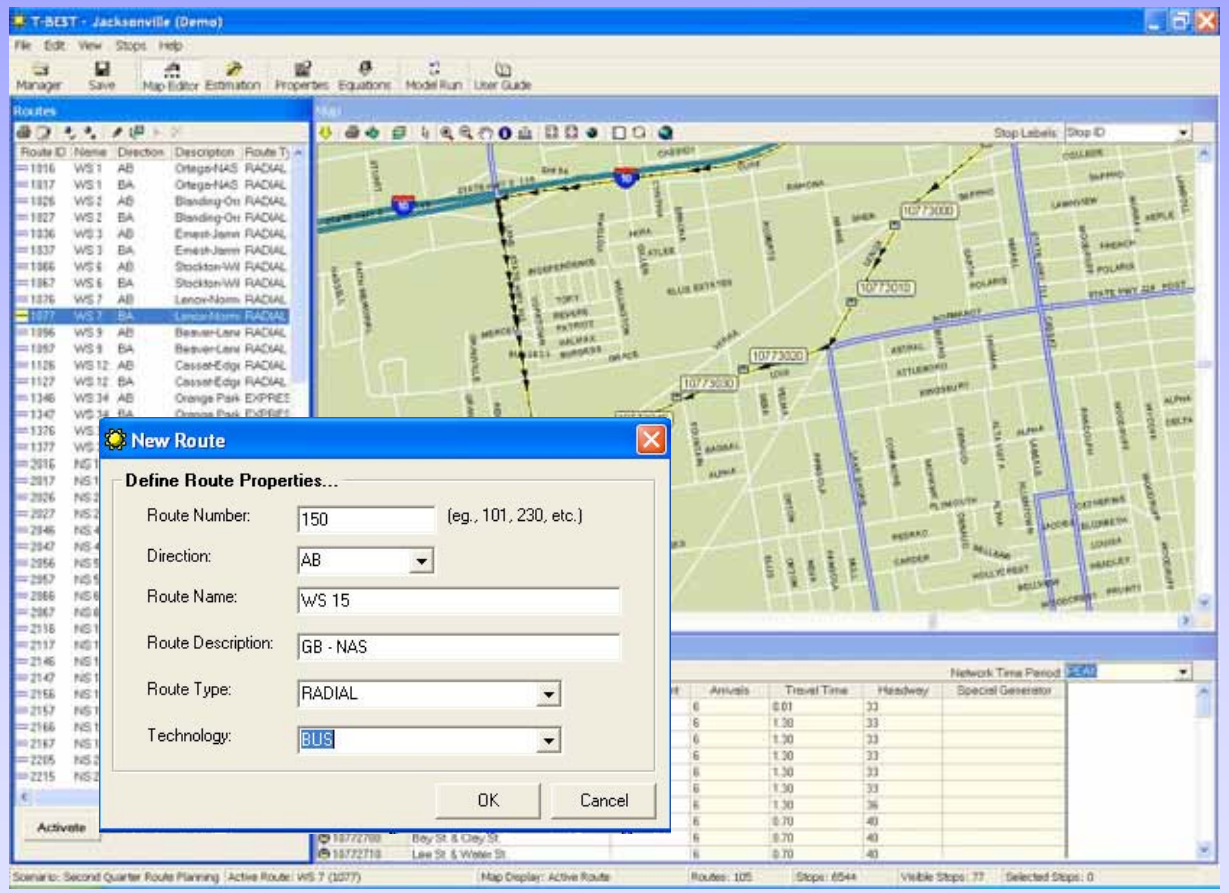
System Properties



- Fare Structure
- Transfer Hubs
- Interlined Routes
- Local Employment Data
- Socio-Economic growth applied to future year forecasts

T-BEST Software

Scenario Editor



- Integrated editing, coding and analysis environment
- GIS-enabled network editing
- Time Period specific variables
- Stop-level socio-economic updates

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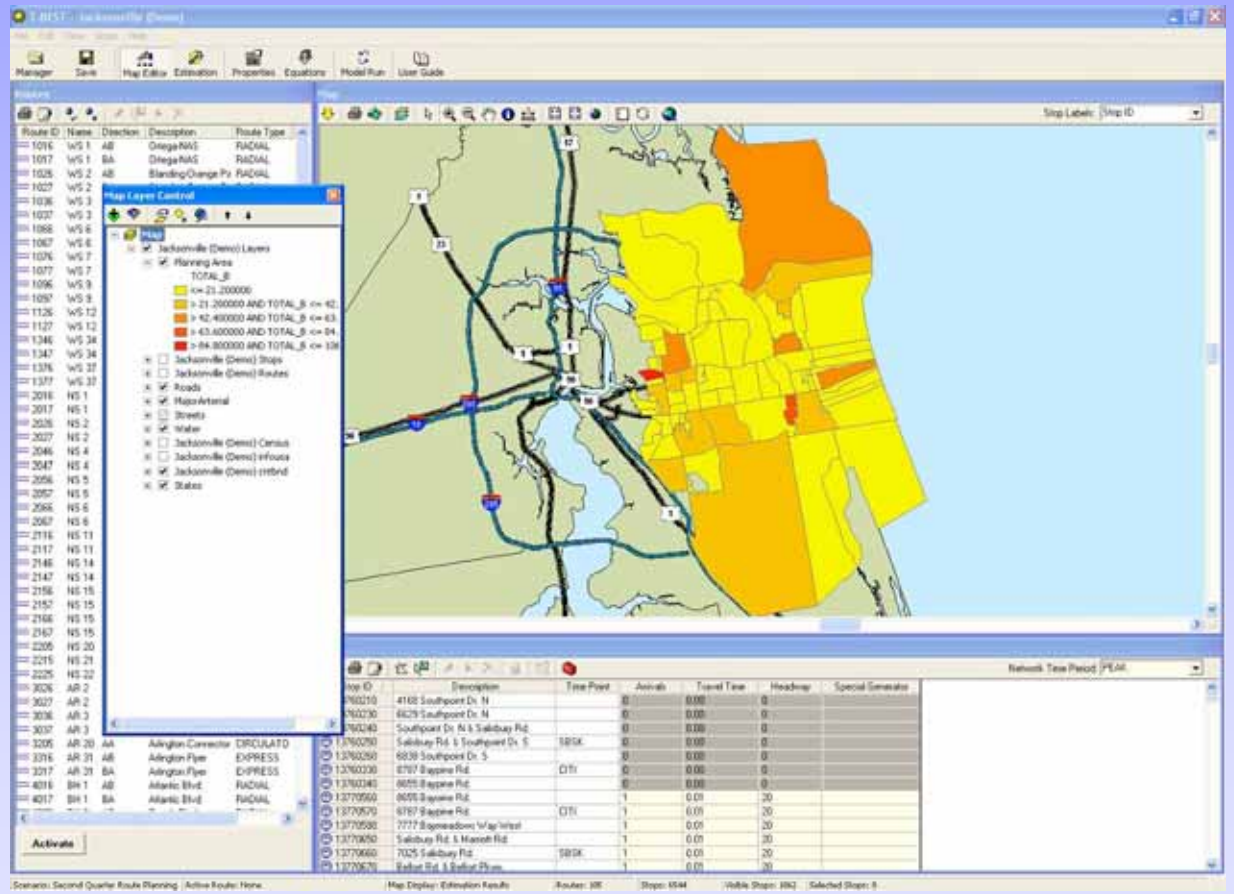
GIS Features



- T-BEST developed with ArcObjects
- Add local data or images
- Edit Symbols and Labels
- Save custom Map setup with Scenario

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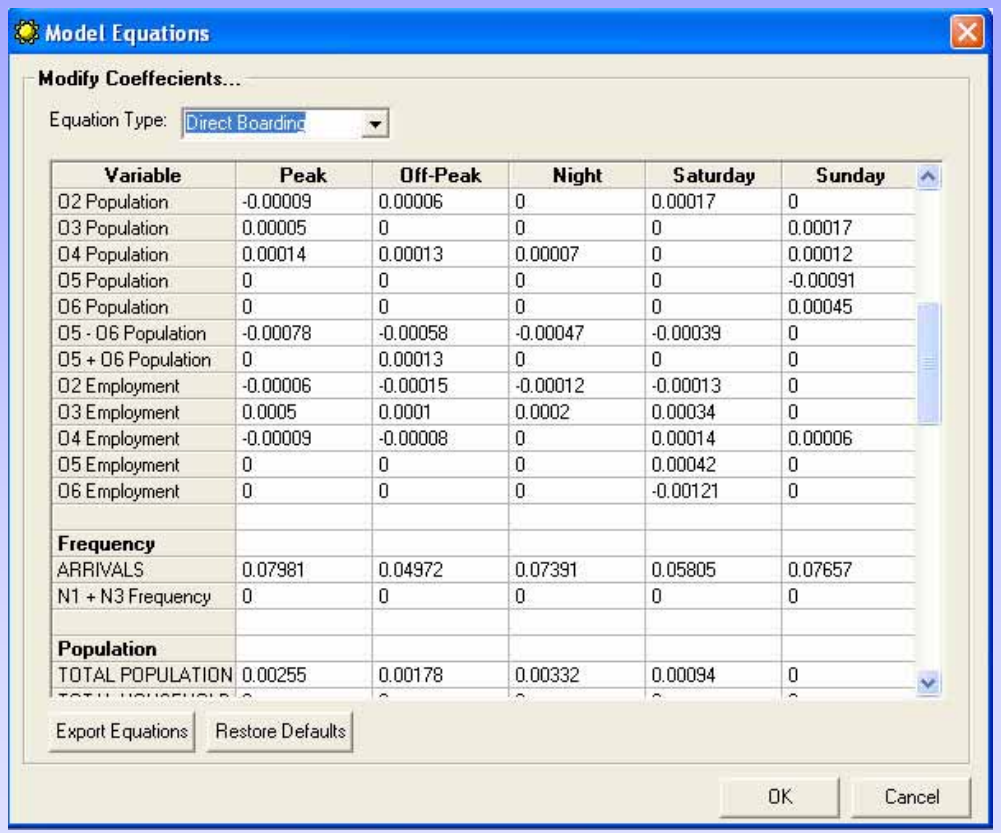
Model Equations



Variable	Peak	Off-Peak	Night	Saturday	Sunday
O2 Population	-0.00009	0.00006	0	0.00017	0
O3 Population	0.00005	0	0	0	0.00017
O4 Population	0.00014	0.00013	0.00007	0	0.00012
O5 Population	0	0	0	0	-0.00091
O6 Population	0	0	0	0	0.00045
O5 - O6 Population	-0.00078	-0.00058	-0.00047	-0.00039	0
O5 + O6 Population	0	0.00013	0	0	0
O2 Employment	-0.00006	-0.00015	-0.00012	-0.00013	0
O3 Employment	0.0005	0.0001	0.0002	0.00034	0
O4 Employment	-0.00009	-0.00008	0	0.00014	0.00006
O5 Employment	0	0	0	0.00042	0
O6 Employment	0	0	0	-0.00121	0
Frequency					
ARRIVALS	0.07981	0.04972	0.07391	0.05805	0.07657
N1 + N3 Frequency	0	0	0	0	0
Population					
TOTAL POPULATION	0.00255	0.00178	0.00332	0.00094	0

- Edit Direct and Transfer Boarding Coeffecients

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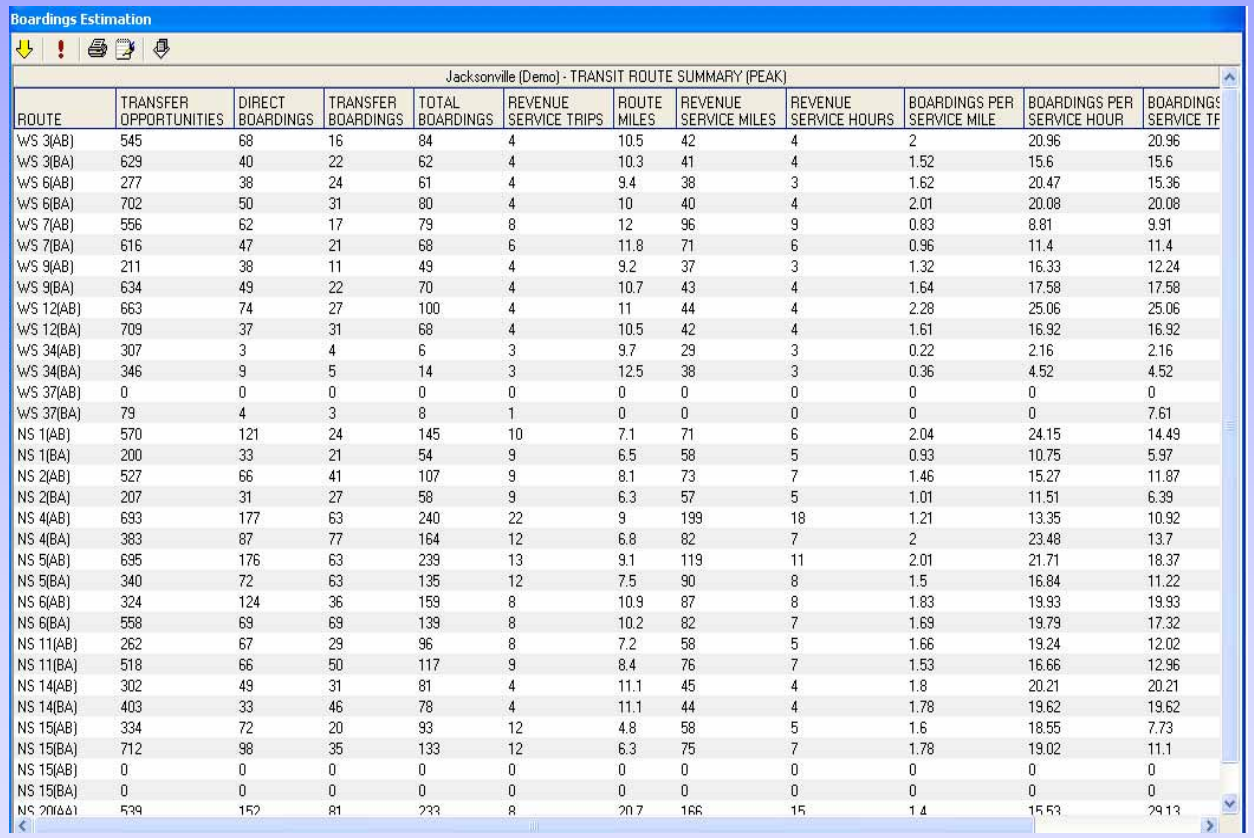
Interactive Reporting


Boardings Estimation

Jacksonville (Demo) - TRANSIT ROUTE SUMMARY (PEAK)

ROUTE	TRANSFER OPPORTUNITIES	DIRECT BOARDINGS	TRANSFER BOARDINGS	TOTAL BOARDINGS	REVENUE SERVICE TRIPS	ROUTE MILES	REVENUE SERVICE MILES	REVENUE SERVICE HOURS	BOARDINGS PER SERVICE MILE	BOARDINGS PER SERVICE HOUR	BOARDINGS SERVICE TF
WS 3(AB)	545	68	16	84	4	10.5	42	4	2	20.96	20.96
WS 3(BA)	629	40	22	62	4	10.3	41	4	1.52	15.6	15.6
WS 6(AB)	277	38	24	61	4	9.4	38	3	1.62	20.47	15.36
WS 6(BA)	702	50	31	80	4	10	40	4	2.01	20.08	20.08
WS 7(AB)	556	62	17	79	8	12	96	9	0.83	8.81	9.91
WS 7(BA)	616	47	21	68	6	11.8	71	6	0.96	11.4	11.4
WS 9(AB)	211	38	11	49	4	9.2	37	3	1.32	16.33	12.24
WS 9(BA)	634	49	22	70	4	10.7	43	4	1.64	17.58	17.58
WS 12(AB)	663	74	27	100	4	11	44	4	2.28	25.06	25.06
WS 12(BA)	709	37	31	68	4	10.5	42	4	1.61	16.92	16.92
WS 34(AB)	307	3	4	6	3	9.7	29	3	0.22	2.16	2.16
WS 34(BA)	346	9	5	14	3	12.5	38	3	0.36	4.52	4.52
WS 37(AB)	0	0	0	0	0	0	0	0	0	0	0
WS 37(BA)	79	4	3	8	1	0	0	0	0	0	7.61
NS 1(AB)	570	121	24	145	10	7.1	71	6	2.04	24.15	14.49
NS 1(BA)	200	33	21	54	9	6.5	58	5	0.93	10.75	5.97
NS 2(AB)	527	66	41	107	9	8.1	73	7	1.46	15.27	11.87
NS 2(BA)	207	31	27	58	9	6.3	57	5	1.01	11.51	6.39
NS 4(AB)	693	177	63	240	22	9	199	18	1.21	13.35	10.92
NS 4(BA)	383	87	77	164	12	6.8	82	7	2	23.48	13.7
NS 5(AB)	695	176	63	239	13	9.1	119	11	2.01	21.71	18.37
NS 5(BA)	340	72	63	135	12	7.5	90	8	1.5	16.84	11.22
NS 6(AB)	324	124	36	159	8	10.9	87	8	1.83	19.93	19.93
NS 6(BA)	558	69	69	139	8	10.2	82	7	1.69	19.79	17.32
NS 11(AB)	262	67	29	96	8	7.2	58	5	1.66	19.24	12.02
NS 11(BA)	518	66	50	117	9	8.4	76	7	1.53	16.66	12.96
NS 14(AB)	302	49	31	81	4	11.1	45	4	1.8	20.21	20.21
NS 14(BA)	403	33	46	78	4	11.1	44	4	1.78	19.62	19.62
NS 15(AB)	334	72	20	93	12	4.8	58	5	1.6	18.55	7.73
NS 15(BA)	712	98	35	133	12	6.3	75	7	1.78	19.02	11.1
NS 15(AB)	0	0	0	0	0	0	0	0	0	0	0
NS 15(BA)	0	0	0	0	0	0	0	0	0	0	0
NS 20(AA)	539	152	81	233	8	20.7	166	15	1.4	15.53	29.13

Route-level Performance Measures

Aggregate Records by:

- Route(s)
- Sub-Area
- Selection Set
- Planning Area

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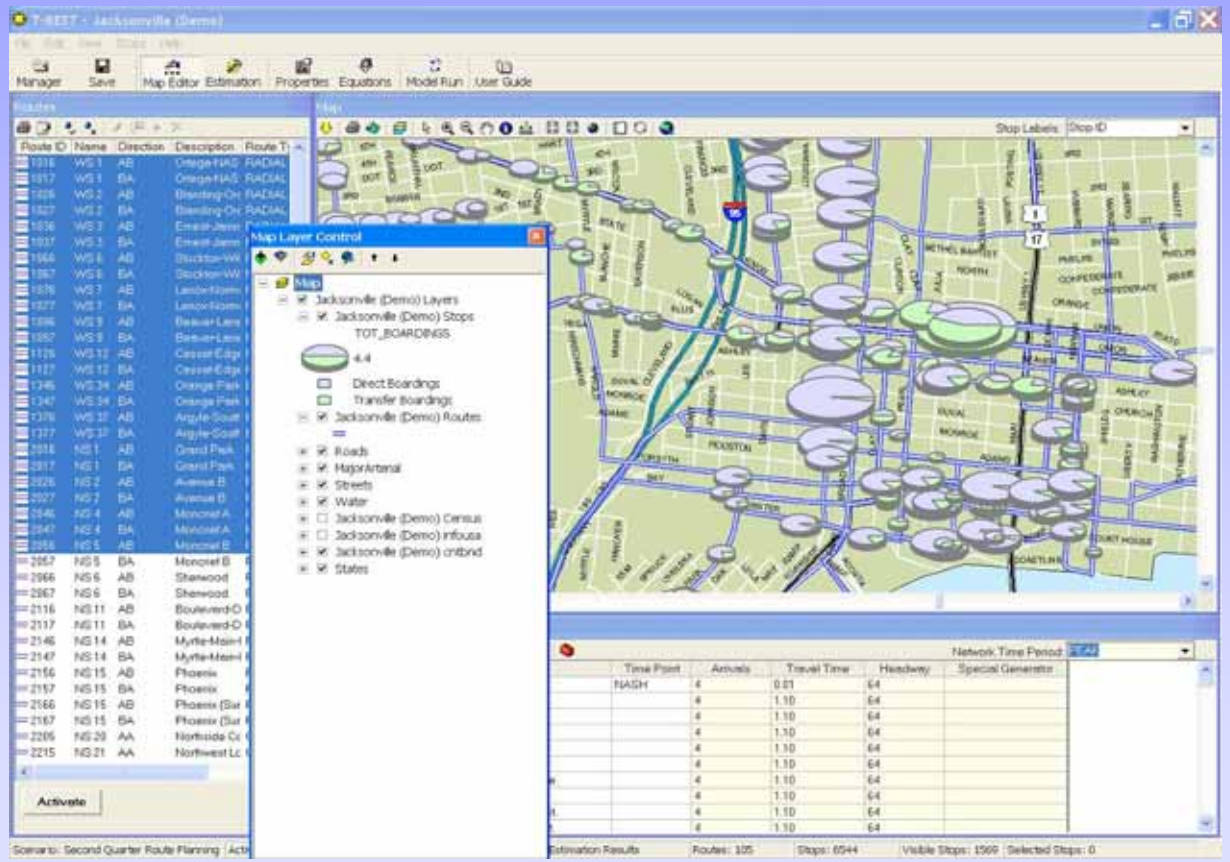
Analysis Mapping



- Automated Map Analysis
- Flexible Mapping Environment

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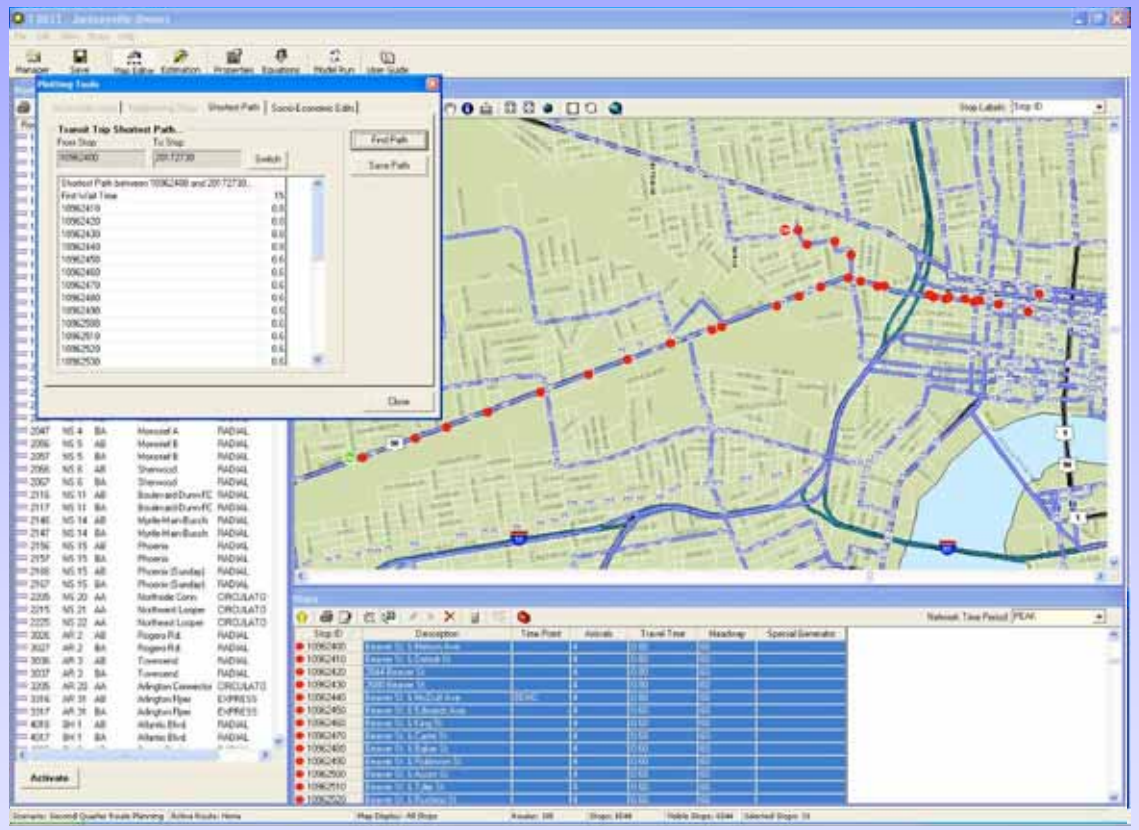
Quality Control Measures



- Visualize Model Accessiblity Calculations with impedance (H1-H5)
- Locate Neighboring Stops (N1 – N3)
- Shortest Path Algorithm

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T-BEST Software

Model Engine

- Time Period Specific output for each stop
- Option to run for selected time-periods
- Optomized model calculations to run only necessary components

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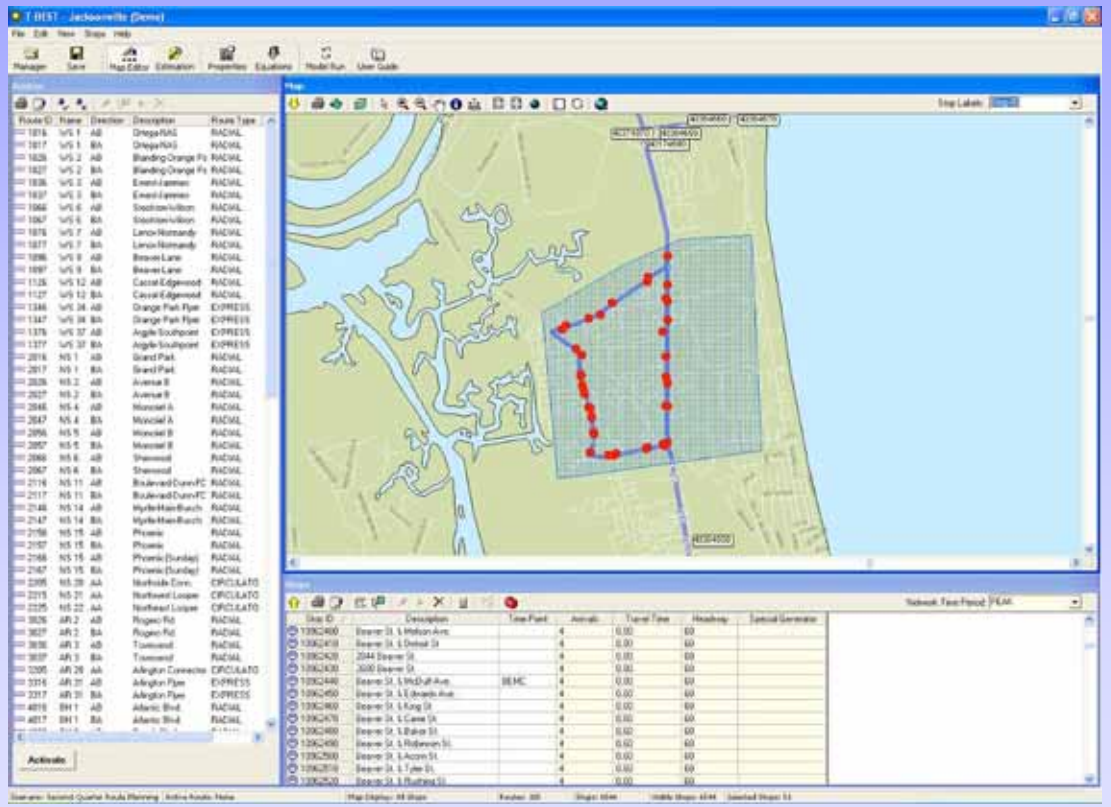
Additional Features



- Direct conversion of T-BEST Map into ArcMap Layout
- Export all Reports or lists to delimited text files
- Export Map to raster or PDF
- Save Sub-Areas and Selection Sets for use in multiple Scenarios
- Scenario Log
- Extensive User-Guide

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T-BEST Implementation

Default Implementation

- Download & Install Software (www.tbest.org)
- Default coefficients provided
  - Calibration for Portland, Oregon in progress
- Calibration to Local Area
  - Local Stop Level Ridership Data
  - Develop Socio-Economic data
  - Create T-BEST Transit Network
  - Re-estimate and Re-calibrate

T-BEST Implementation

Custom Implementation

- Software
- Data Model
- Interface with Systems Planning and Operational Software
- Scale T-BEST to your Enterprise Environment

Database	Network Structure
Oracle	Oracle Spatial
SQL Server	SDE

T-BEST Implementation

- Recommended Hardware
  - 2.0 gHZ Pentium M Processor or higher
  - 1 GB Ram
- Required Software
  - Window 2000 or XP
  - ArcView 9.x

Conclusions

- T-BEST provides a powerful framework for modeling transit ridership at stop level
- Incorporates effects of accessibility and connectivity on ridership
- Accessibility and impedance computations very sophisticated, accurate, and automated in software
- More precisely accommodates effects of service span and frequency (temporal aspects)
- Focus on ease of use and quick response capability

Future Enhancements

- Enhancements for T-BEST 3.0:
  - Automated calibration and scaling procedures
  - T-BEST Analyzer
  - Enhance stop-level accessibility measure using alternative methodologies (e.g., network-based, regression, TLOS)
  - Statewide Transit Network Input

Future Enhancements

- Enhancements for T-BEST 4.0:
  - Develop sets of equations for different urban area sizes and trip purposes
  - Spatial distribution of boardings to develop a stop-to-stop O-D matrix
  - Greater sensitivity to route type, technology type, park-n-ride facilities, and special generators

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Questions??

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